

The Capillary Circulation

Functional histology:-

- Capillaries are the smallest type of blood vessels which form the junction between the arterial and the venous ends of the circulatory system.
- Generally speaking a capillary is about 750µm in length and 60µm in diameter.
- Only 25% of all the capillaries are open while the remaining is closed.
- Histologically capillaries are either of 2 types fenestrated and non-fenestrated.

a)Non-fenestrated capillaries:-

- Their wall consists of one single layer of endothelium resting on a basement membrane. The edges of these endothelial lining cells overlap forming an intercellular cleft.
- This is the more common type of capillaries, present in muscles, connective and adipose tissues.

b)Fenestrated capillaries:-

- They simulate the non-fenestrated type but with fenestrations or openings within the cells.
- They are present in the renal glomeruli and in the intestine.

c)Blood sinusoids:-

- They also simulate the 1st type but the wall includes wide gaps which give this type of capillaries a very high degree of permeability.
- They are in the liver and spleen
- The inlet and outlet of capillaries are guarded, each by a tiny sphincter called the pre and post capillary sphincters respectively,

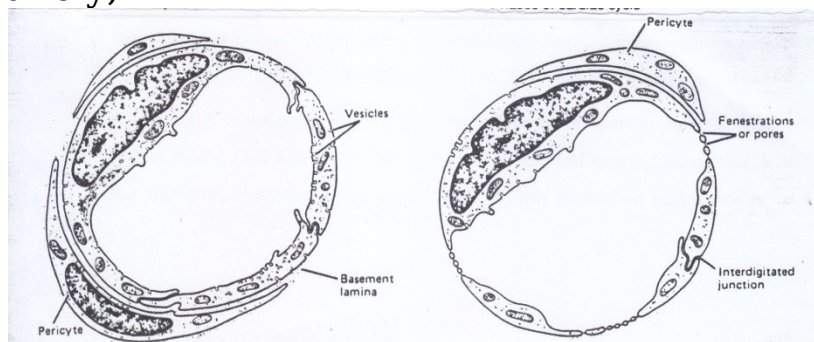


Fig. (1) Histological types of capillaries

Functions of the capillary circulation:-

- 1-It is responsible for determination of the *skin colouration*.
- 2-It is responsible for the formation of the *interstitial tissue fluid*.

3-It is responsible for nutrition of the tissues with *oxygen and different nutrients*.

4- It is responsible for drainage of *waste products* from these tissues.

The capillary blood flow:-

-The capillary blood flow is not a continuous but an intermittent type of flow

-This is known as the capillary vaso-motion.

Mechanism of the capillary vasomotion:-

-The pre-capillary sphincters are richly supplied by the sympathetic nerve fibers, they gradually constrict under the sympathetic tone and with maximum constriction the capillaries are fully closed and blood inflow stops temporarily.

-With full closure of these capillaries there will be ischemia, hypoxia and acidosis which eventually will dilate these sphincters leading to reopening of these capillaries, so that blood re-inflows into them.

-Blood flow will wash out all metabolites relieving hypoxia, ischemia and acidosis with the sympathetic tone regaining its full activity gradual.

-The intermittent closure occurs at a rate of 6-12/min.

The Capillary Blood Pressure:-

-At the arterial end it is 35 mmHg.

-At the venous end it is 15 mmHg.

-The mean capillary blood pressure is 25 mmHg.

-The capillary pulsations at the arterial end are normally invisible because they are very faint.

-These pulsations become visible only with any condition of hyper-dynamic circulation as in arterial vasodilatation, AV shunts, thyrotoxicosis and aortic incompetence.

-They are tested by the nail bed test; where the thumb' nail is pressed by the bulb of the opposite thumb finger, a line of demarcation appears and if this line starts to move fore and backwards then there are visible pulsations.

Factors affecting the capillary blood pressure:-

1-The pre-capillary sphincter:-

It is a tiny sphincter which is richly supplied by the sympathetic nerve fibres and receives the ordinary sympathetic tone.

-If it is constricted then the capillary blood flow will be reduced and the capillary blood pressure will decrease and v.v.

2-The post-capillary sphincter:-

-It constitutes about 1/5 of the pre-capillary sphincter.

-It is highly sensitive to any venous obstruction which markedly increases it and in turn increases the capillary blood pressure.

3-The arterial blood pressure:-

-Any acute increase of the ABP is associated with a concomitant increase of the capillary hydrostatic pressure.

-Any acute decrease of the ABP as in hemorrhage is associated with a concomitant decrease of the capillary hydrostatic pressure.

-A chronic increase of the ABP is associated with a reflex constriction of the pre-capillary sphincter.

4-The venous pressure:-

-There is no boundary between veins and capillaries so that any increase of the venous pressure is almost reflected backwards to the capillaries that's why any venous obstruction is always followed by oedema.

Capillaries are characterized with 2 important criteria; fragility and permeability.

(A)The capillary fragility:-

-It means how much pressure the capillary wall can adapt or accommodate without being ruptured.

-The fragility is dependent upon healthy capillary wall which is formed mainly of collagen.

-Any disruption of the collagen synthesis will markedly affect the wall integrity and increase its fragility.

-Factors affecting the integrity of collagen synthesis in the capillary wall:-

1- Intact protein synthesis of collagen.

2- Adequate supply of vitamin C and Rutin

-Causes of increased capillary fragility:-

1- Excess cortisol which disrupts collagen synthesis.

2- Deficiency of vit.C and /or Rutin.

3- Inflammation of the walls of capillaries; capillaritis.

4- Excess exposure to sun rays.

-Testing of capillary fragility; Hiss test:-

Venous drainage is obstructed by wrapping a sphygmomanometer cuff around the upper arm with an occluding pressure of 80mmHg for 8 minutes. Thereafter the

pressure is released and a skin area of 5 cm diameter in the ante-cubital fossa is examined for petechiae. Normally the number of these petechiae should not exceed 20.

(B)The capillary permeability:-

- Permeability of a membrane is defined as its criterion that allows the passage of substances through it in either or in both directions.
- Permeability of the capillary wall is an important determinant factor which controls the interstitial tissue fluid formation.

Permeability is affected by the following factors:-

- 1-Serum Ca ion level:-Ca solidifies the protein cement bridges between the cells in the capillary wall, so any decrease of the Ca ion level will increase the capillary wall permeability.
- 2-Acidosis:-it increases Ca ion solubility thus preventing its binding to the protein bridges.
- 3-Hypoproteinaemia:-as some of the plasma proteins block the capillary wall intercellular pores.
- 4-Capillary vasodilatation:- it automatically increases permeability as it widens the pores.
- 5-Ischemia and hypoxia:- they both lead to capillary vasodilatation. They may also lead to acidosis.
- 6-Vasodilators as histamine and bradykinin ; they increase the capillary permeability.
- 7- Vit. C and Rutin deficiency:-they decrease the capillary permeability.
- 8-Extremes of temperature decrease the capillary permeability.

The Trans-capillary transport of substances:-

This may occur through one or more of the following mechanisms:-

- 1-Diffusion:-***it is the commonest way used by water and fat soluble substances.
 - Water soluble substances as Na, K, glucose and urea pass through intercellular pores.
 - Fat soluble substances as CO₂ and ether pass through lipid bi-layer of the membrane, that's why they pass easier and faster, they can pass through the most of the whole circumference.
 - Diffusion of water (osmosis):-it occurs through both channels
- 2-Vesicular transport:-***

-It used for large molecules as globulins, where they are engulfed by the cell wall membrane on one side (endocytosis), then pass to the opposite side of the cell wall where the vesicles are ruptured (exocytosis).

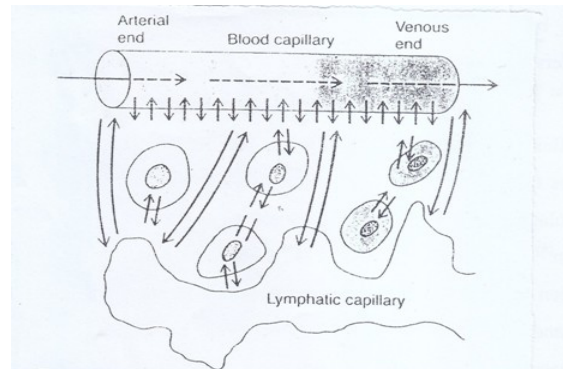


Fig (2) Vesicular transport

3-Filtration: -this is the passage of fluid across capillary pores under the force of hydrostatic pressure gradient.

4-Diapedesis:-

-This is specified for cellular elements of the blood namely WBCs.

-They send a pseudopodium out of the wall through one of the pores, fix it to the interstitium, then through it drags the remaining part of the cell to the exterior of the capillary.

The Interstitial tissue fluid formation:-

-At the arterial end of capillaries about 20 liters of fluid are filtered daily into the interstitium.

-At the venous end about 18 liters are reabsorbed daily, the remaining 2 liters are delivered by the lymphatic system.

-The interstitial fluid acts as a device for nutrition and drainage for the tissues.

-Mechanism of tissue fluid formation:-

A group of forces called starling forces act at the arterial and venous ends of the capillaries for formation of the tissue fluid. They are simply the filtering and the re-absorptive forces

	At the arterial end of capillaries		At the venous end of capillaries	
Filtration forces:-	1-Capillary hydrostatic pressure:-	mmHg g 35 +	1- Capillary hydrostatic pressure:-	mmHg g 15 +

	2-Tissue fluid osmotic pressure:-	3 = 38	2-Tissue fluid osmotic pressure:-	3 = 18
Re-absorptive forces:-	1-Plasma osmotic pressure:- 2-Interstitial hydrostatic pressure:-	25 + 1= 26	1-Plasma osmotic pressure:- 2-Interstitial hydrostatic pressure:-	25 + 1= 26

-At the arterial end the net resultant force = $38 - 26 = 12$ mmHg sub serving filtration.

-At the venous end the net resultant force = $26 - 18 = 8$ mmHg for re-absorption

Factors affecting the tissue fluid formation:-

1- Starling group of forces.

2-The capillary permeability:-any increase of the capillary permeability is associated with a proportionate increase of the rate of fluid formation through filtration.

Oedema

It is defined as any increase of the tissue fluid volume.

-Types:-

1-Intracellular oedema:-where the intracellular fluid volume is increased.

-Causes:-

a-Depression of the Na-K pump, leading to an increase of the intracellular Na concentration with water flowing into the cells.

b- Increase of the cell wall permeability due to allergy, inflammation, ischemia or hypoxia.

2-Extracellular oedema:-

-The interstitial fluid volume is increased.

-Causes:-

a- Increase of the capillary hydrostatic pressure:-

-Any increase of the capillary hydrostatic pressure results in an increase of the filtering forces with excess tissue fluid formation.

-It is increased in cases of salt and water retention as in cushing's syndrome, arteriolar vasodilatation as in allergy or veinular vasoconstriction as in heart failure

b- Decrease of the plasma oncotic pressure:-

-It occurs in cases of liver cell failure, or renal failure

c- Increase of the capillary permeability: - as in severe allergic reactions

d- Obstruction of the lymphatic drainage system: - as in Filariasis